

immediately above the surface extending to about 800 meters, and not in an anomalous air current aloft. Wyatt and Lawing have stated that inversions were not encountered in the few aerological trips they made over the ocean and the Imperial Valley.⁵ This is in accordance with my conclusions; they should be found only over the narrow strip paralleling the coast.

CONCLUSIONS

Temperatures aloft in other than the summer months normally decrease with elevation, or, occasionally, there is a small inversion from one of three causes—radiation and conduction in the layers just above the ground; importation of warm, dry air; or an indraft of relatively warm, moist air from the ocean.

Inversions during the summer are of regular occurrence, usually following a drop in temperature from the surface to 500 meters. The highest temperatures occur near the 1,250-meter level, where they average about 4° C. higher than at the surface, and temperatures comparable to those at the surface are reached at 1,800 or 1,900 meters.

That the summer inversions are not caused by an overflow from ascending air currents in the desert valleys to the east is evident. Prevailing wind directions at all heights are from the ocean. Occasionally a drift from the east is observed when temperatures in the interior are unusually high, but as these high temperatures are caused by anticyclones over the Plateau States, then the winds from this direction are also the result of this same pressure distribution.

As already stated there is a stratum of relatively cool air of oceanic origin over the littoral districts. This stratum is overtopped by warmer air of continental origin that slowly drifts oceanward in the hot season. These conditions are brought about by the broader relations of marine and continental climates and may be found in their fullest development in the border zone between the two climates.

DISCUSSION

Chairman Lastreto felt the paper was too technical for a layman like himself to discuss, though he confessed to

⁵ Lieut. B. H. Wyatt and M. R. Lawing. Discussion of Papers in Bulletin Am. Metl. Society, Nov., 1923. Pp. 154-157.

a deep emotion at the ability with which many old theories had been blasted.

Mr. Gordon wondered where the rising hot air goes from Yuma; it goes up and should come down somewhere, but where?

Mr. Blake stated that Sonora storms are caused by a meeting of the sea and land winds over the mountains; but just how far westward the convectional currents out of the Imperial Valley extend is unknown and is a problem that needs study.

Mr. Gordon said there should be currents aloft out of the valley in practically all directions.

Mr. Blake replied that strong convection over the valley had not been experienced by flyers whom he had interviewed. No extreme bumpiness was reported at the elevations where it is usually found.

Mr. Young asked if different directions of wind were found at different times of the day from the various pilot-balloon observations, to which Mr. Blake replied that while he used the 1 p. m. observations, the aerographers at North Island believed that there was little difference during the 24 hours. Nocturnal data, however, were not available and therefore the answer was in doubt.

Major Bowie explained that by means of numerous pilot-balloon reports received in the San Francisco office from stations in the southwestern quarter of the United States it is a simple matter to construct the isobars for various elevations up to 4 or 5 kilometers. Thus the changes in wind direction at various levels, ranging from an inflowing circulation at the surface to an outflowing circulation aloft, indicate that as we strip off the isobaric surfaces over the interior, one by one, the low at the surface gradually gives way to a high in the upper air.

At the higher elevations the barometric gradient is actually outward instead of inward. We are in such a case dealing with a theoretical thermal cyclone as described by Ferrell. The explanation of the wind circulation aloft at San Diego is very easy, it seems to me; the air is moving in a wide circle, and while it may originate in the region to the southward of the Imperial Valley it passes seaward in a circuitous route aloft, and when observed at San Diego is moving in a clockwise direction, because at high levels it constitutes the outflow of air from the anticyclone capping the low-pressure area, which exists only in the lowest atmospheric strata.

THE MEASUREMENT OF SKY COLORING

By FRANZ LINKE

[Frankfort on the Main, Germany]

In the year 1922 I approached Prof. W. Ostwald, of Grossbothen, with a request for the making in his laboratory of a technical, well-defined, and certainly reproducible blue scale for the estimation of the color of the sky. With a well-known obliging interest in all applications of his color lore Professor Ostwald undertook the task and put at my disposal a rather large number of copies of a blue scale in seven parts, which showed logarithmic transitions from pure white to ultramarine blue. I then numbered the pure white 0 and the ultramarine 14, so that the even numbers indicated the several color steps of the scale and the odd numbers interpolations. Since that time the scale has been employed at many places for the estimation of the coloring of the sky. Professor Ostwald himself reports on the color-technical principles of this blue scale, so that I

have only to make statements on the method and purpose of the observations and the results to date.

Method of observation.—The observer places himself with his back to the sun and observes for at least 30 seconds the bluest point in the sky, which is 70° to 90° distant from the sun in the direction of its meridian. Without removing his eyes from the sky the observer arbitrarily opens the scale at a tone and quickly brings it into the range of the eye so that it comes into the light of the sun. After some practice, even when the exact coloring of the sky does not contain white and blue only, the observer forms an opinion whether the blue tone of the scale is lighter or deeper as compared with the blue of the sky. The scale made up in book form is then turned until the observer either finds a color tone in sufficient agreement with the coloring of the sky or is

convinced that the blue coloring of the sky lies between two successive tones of the scale. Some practice and willingness are necessary especially when—as often happens—there are present in the sky green, red, or black tones in addition to white and blue. The observer soon becomes accustomed to focus the sense of sight on the blue coloring and eventually to pay no attention to the secondary tones. Only at great heights, either in aircraft or on a high mountain, is the blue of the sky so mixed with black that there are noticeable differences relative to the color scale made up of blue and white alone. Here it is necessary that the estimation of the blueness be made always by the same observer or that several observers practice one after another. If the observer holds the blue scale in the shade and looks quickly from the color scale to the darkest part of the sky and then back, then on an average he will estimate two or three shades lower, a result of the fact that the color tones of the scale are dependent on the amount of illumination.

It is sufficient to carry out such observations two or three times daily at determined hours, and of course most practicably at the international hours, 7 or 8 a. m., noon to 2 p. m., and about 7 p. m. (at least in the summer). In winter a 10-hour period is to be recommended. In the statistical enumeration there is noted how often in a given month the different scale values were found, that is in percentage of the total number of observations. Since the full number of observations, two or three, will not be available on all days a single value for each day determined by averaging must be considered in monthly means or the calculation must be made for each observation hour.

Results of observation.—Unfortunately, data on the coloring of the sky for a long period of years are not

available. On the basis of my Argentine series (1923) I was first able to state that the blue coloring of the sky (B) stands in logarithmic relation to the turbidity factor (T). There exists the following relation, $B = 12.0 - 14.5 \log. T$. On our Lapland expedition (1927) I ascertained that polar air has a deeper (blue) coloring than sea or tropical air. Before approaching cloudiness there occurs a marked decrease in blue coloring, thus a lighting up of the sky, caused by hygroscopic enlargement in the aerosole (dispersed particles suspended in the atmospheric gases).

Never could there be recognized a daily period in blue coloring, although it must be assumed as certain that the darkest point of the sky is darker, taken absolutely, when the sun is low than when it is high. But since the blue scale is evidently made lighter in equal measure through illumination by the sun, this effect is canceled, so that with this blue scale one arrives at an estimate that is independent of the sun. F. Loewe found in his aircraft flights an increase in blue coloring from 6.4 at the ground to 11.8 at the elevation of 6km. (0–14 scale).

The purpose of this estimation of the blue coloring of the sky is a rough approximation of the purity of the air; that is, of the number and size of the aerosole. Heretofore there have been in use in widely different parts of the earth over 100 scales of blue. It is to be desired that results of observations be made known from time to time; with careful observance of the above directions these will serve as comparable data.

Sets of the blue scale.—The Meteorologisch-Geophysikalische Institute, Frankfurt on the Main, receives the scales in rather large orders from the laboratory of Professor Ostwald, and forwards them in return for the manufacturing cost of 3.5 marks plus postage.—Translated by W. W. Reed.

BLUE-SKY MEASUREMENTS AT WASHINGTON, D. C.

By IRVING F. HAND

[Weather Bureau, Washington, July 31, 1928]

The method of obtaining and utilizing blue-sky measurements has been described in the above article by F. Linke. Since the publication of my brief note on "Blue-sky measurements" in the MONTHLY WEATHER REVIEW for May, 1927, no skies of a deeper blue than 8, or of a whiter color than 4 have been observed. A summary of all observations to date is given in Table 1.

Visibility and polarization show the greatest correlation with sky color. However, due to topography and other reasons, such as low haze, fog in the valley, poor illumination owing to position of the sun, cloud arrangement, etc., it often happens that the visibility is relatively poor with a deep-blue sky; an effect which is masked in the table by the large number of observations. Polarization is less affected by such causes, however, as these measurements are generally made in the same sector of the sky as the color measurements, or to be more exact, at a point 90° from the sun and in his vertical, with a solar altitude of 30° (air mass=2.0). It is thus evident that when observing the sky for color at a comparatively high angle less interference due to atmospheric pollution or to optical phenomena will occur than when measuring visibility through a layer of the lower air 50 or more miles in extent.

TABLE 1.—Relation between sky color and other meteorological elements

Color scale	Visi- bility	Skylight polar- ization	Solar ra- diation at normal in- cidence. Air mass =2.0	Number of dust particles per cubic centi- meter	Vapor pressure	Wind	Average number of days since precipitation occurred
	Miles	Per cent	Gr. cal./cm. ²		Inch	M. p. h.	
4.....	14.9	52.6	1.05	911	.702	4.3	2.4
5.....	23.3	56.5	1.12	702	.697	5.4	1.8
6.....	37.8	59.0	1.18	521	.520	8.4	2.3
7.....	44.4	61.1	1.25	811	.382	10.7	1.3
8.....	50.0	63.0	1.37	160	.160	30.0	10.0

¹ Immediately following rain.

The irregular relationship between sky color and the number of dust particles in the atmosphere is due to the location of the observatory in a suburb of Washington, as an easterly component of wind will give dust-count values of city conditions, while a westerly component will give country values. It was found that by eliminating a small number of observations taken with a deep-blue sky in which the wind was from the east and the number of dust particles several hundred per cent over normal, the